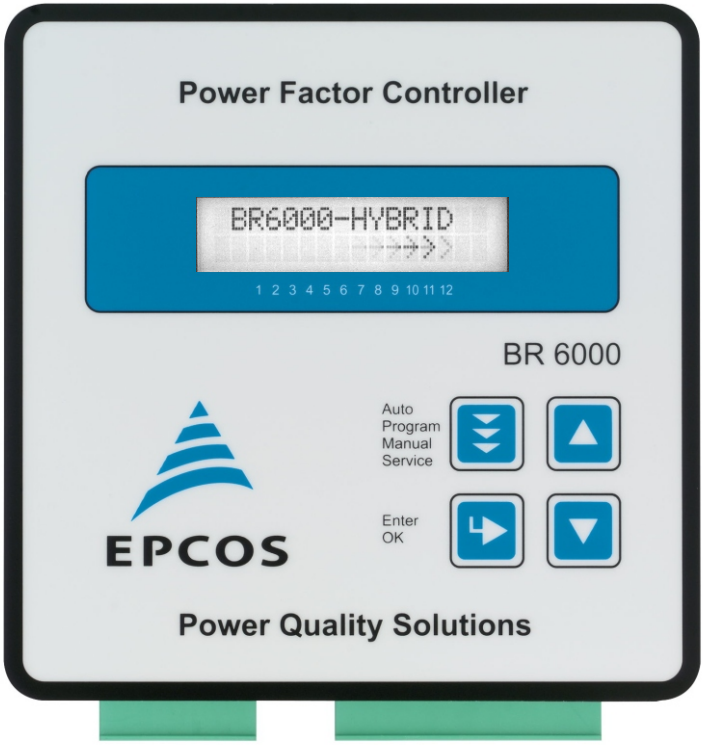
Power Factor Controller BR6000-T6R6

for combined dynamic and standard compensation



Manual

Version 4.0 E

EPCOS AG
Power Quality Solutions
P.O. Box 80 17 09
D-81617 Munich
St.-Martin-Str. 53
PFC-Hotline
Tel. ++49 89 636 - 25533
Telefax ++49 89 636 - 22748
internet: http://www.epcos.com

CAUTIONS:

1. High voltage !

2. BR6000 may only be used indoor !

3. Make sure that discharge time set in controller matches capacitor discharge time !

CONTENTS

Section 1	General / type series and accessories		2
Section 2	Installation of the controller / connection diagram		4
	2.1	Current measurement	5
	2.2	Programming of phase-correction	
	2.3	Alarm output / error messages	6
Section 3	Operating modes		6
Section 4	Automatic operation / display functions		7
Section 5	Programming		
	5.1	Program menu	8
	5.2	Programming lock	11
Section 6	Manual operation / Programming of fixed stages		12
Section 7	Service menu		13
Section 8	Expert mode		13
	8.1	Expert mode 1	
	8.2	Expert mode 2	14
Section 9	Control principle		15
Section 10	Interface		16
Section 11	Initial operation		16
Section 12	Maintenance and warranty		16
Section 13	Troubleshooting		17
Section 14	Technical data		18
Annex:	Annex 1	Table of control series Description of control-series editor	19
	Annex 2	Default settings	20
	Annex 3	Application MMI6000	21
	Annex 4	MODBUS protocol	22
	Annex 5	Operating diagram (fast programming)	24

Section1 General

The mixed dynamic power factor controller BR6000-T6R6 represents the consequent follow-up development in the BR6000-series bringing innovative ideas und a multitude of new functions.
It is especially designed for triggering of up to 6 thyristor modules and at the same time up to 6 standard capacitor contactors in combined standard-dynamic PFC-systems.
The switching time of < 20 ms for the dynamic steps delivers extremely fast compensation adjustment for fast changing loads.

Several parameters that can be edited allow an optimized adjustment to different thyristor modules.
The controller is distinguished by user-friendly operation based on menu-guided displays in plain text. Its new features permit an intuitive mode of operation. Easy-to-understand symbols and texts in 8 local languages combine simplest operability with self-evident displays.

Main features:

- ☑ 6 transistor- and 6 relais- switching outputs
- ☑ pre-programmed control series with a self-optimized intelligent control response
- ☑ Control-series editor for user-defined control series
- ☑ Complete menu-guided operation and display
- ☑ Illuminated graphic display with 2 x 16 characters
- ☑ Four-quadrant operation
- ☑ Display of various line parameters (V, I, F, Q, P, S...)
- ☑ Display and monitoring of temperature
- ☑ Monitoring of capacitor power values with accessory MMI6000
- ☑ Storage of maximum line-parameter
- ☑ Manual / automatic operation
- ☑ Programming of fixed stages and the option of skipping individual outputs
- ☑ No-voltage turn-off
- ☑ Error detection for various states and interference-message output
- ☑ Error memory
- ☑ 2nd target power-factor possible
- ☑ Switchboard-integrated housing 144x144x55 mm

Type series and accessories

BR6000-T6R6	6 transistor outputs, 6 relay outputs, 1 alarm relay
BR6000-T6R6/S	- 6 transistor outputs, 6 relay outputs, 1 alarm relay - 1 additional user programmable message relay, - input for second target power factor - with an additional interface RS232 or RS485
Accessories	- Meas. voltage adapter for grids without "N" or voltages > 300V - MMI6000 - MultiMeasuringInterface (for measurement of inherent current of capacitor bank)

The controller is supplied as standard for an operating voltage of 230 VAC (L-N), a measuring voltage of 30...300 VAC (L-N) 50/60 Hz and a measuring current of 5A or 1A (programmable). A voltage converter is required for different operating voltages.

Caution!
Voltages which exceed the allowed voltage range can damage the device!

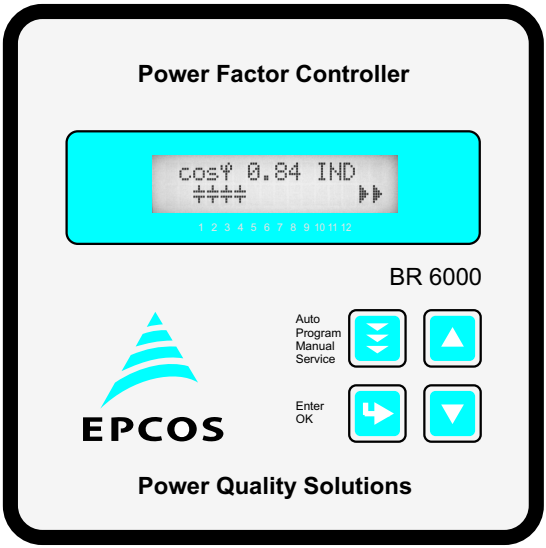


Fig.1 BR6000 front view

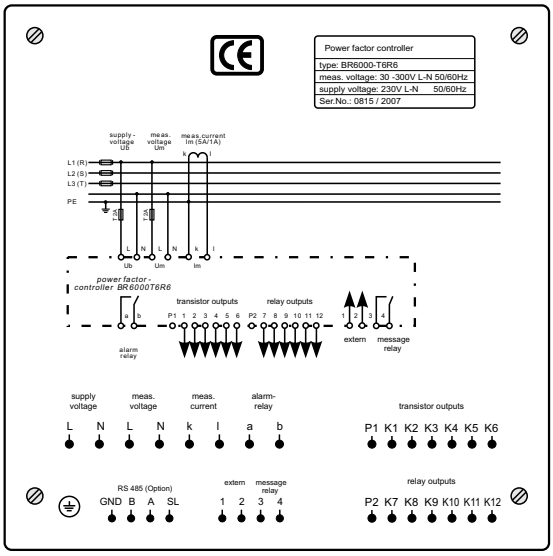
Operating mode
- Automatic
- Programming
- Manual operation
- Service
- Expert mode

Enter / OK
Confirm and store values

Increase selected parameter

Reduce selected parameter

Fig. 2 BR6000 rear view

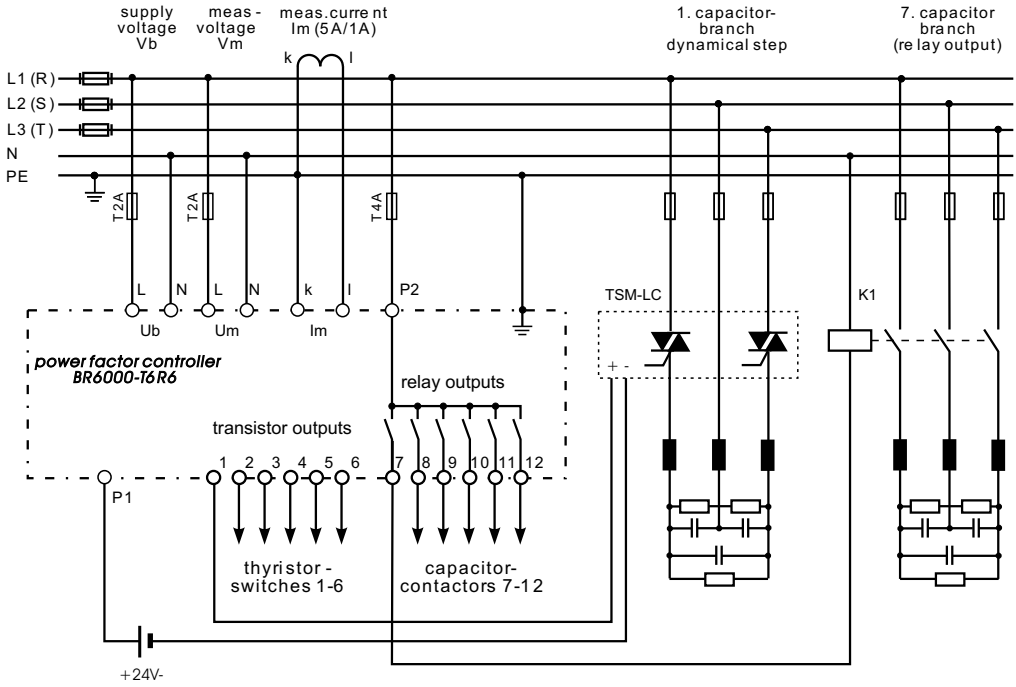


Section 2 Installation and connection of the controller

The BR6000 is designed to be incorporated into the front panel of a PFC-cabinet. It requires a switchboard section of 138 x 138 mm to DIN 43700/ IEC 61554. The controller is inserted from the front and is attached by means of the appended clamps. The controller may be inserted only by qualified technicians and must be operated in accordance with the specified safety regulations.
Before the BR6000 is connected up, all leads and cables must be checked to ensure that no current is flowing through them and the current converter must be short-circuited. Care should be taken to ensure that the measuring voltage and current are in the correct phase position. The measuring-current circuit must be wired with copper leads of 2.5mm^2. The connection should be set up as shown in Fig. 3. The specified safety regulations must be observed.
The measuring voltage may lie in the range from 30 - 300 V and is connected between L1-N (corresponds to 50 - 525 V L-L). A connection between L-L is possible if a measuring-voltage converter is used and the corresponding phase shift U-I is programmed (see Programming).
For higher measuring voltages, a measuring voltage adapter is available as an accessory.
The operating voltage is 230 V +/- 10% and can be connected between L1 - N in a 400-V grid.

The coil voltage for the capacitor contactors and the measuring voltage must be drawn from the same phase conductor, as only the measuring voltage is monitored. (Protection against direct reconnection of the capacitor contactors in the event of momentary single-phase power failure)

Fig. 3: BR6000 Connection plan



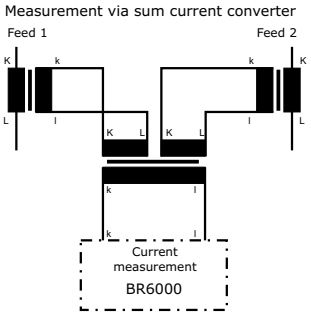
2.1 Current measurement

When installing the current converter, care should be taken to ensure that the load current flows through it. The outputs of the compensation network must be installed behind the current converter (in the direction of current flow). If the BR6000 is connected up via sum-current converters, the overall conversion ratio is entered.

Caution !
Current converter clamps should be grounded on one side !

Example:
C.converter 1: 1000/5A
C.converter 2: 1000/5A
Sum-current converter: 5A+5A/5A

C.converter ratio is: 2000/5A



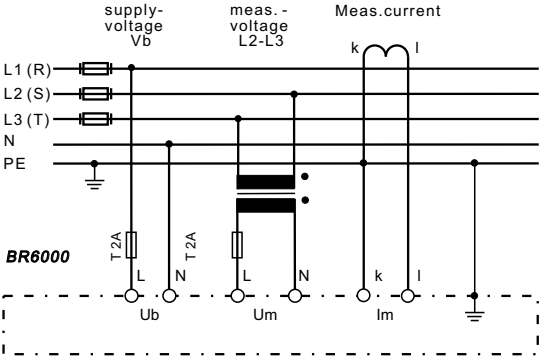
2.2 Programming of phase-correction

Adjustment of phase-correction between voltage and current in the meas. system is done in expert mode 1

Example:

Meas.current: L1
Meas. Voltage L3-L2
(V-converter must be used)

Phase U/I [90°]



using	meas. current	meas. voltage	volt.transformer	phase-angle
standard	L1	L1 - N	no	0°
	L1	L1 - L2	necessary	30°
	L1 (k<->l)	L2 - N	no	60°
	L1	L3 - L2	necessary	90°
	L1	L3 - N	no	120°
	L1	L3 - L1	necessary	150°
	L1 (k<->l)	L1 - N	no	180°
	L1 (k<->l)	L1 - L2	necessary	210°
	L1	L2 - N	no	240°
	L1	L2 - L3	necessary	270°
	L1 (k<->l)	L3 - N	no	300°
	L1 (k<->l)	L3 - L1	necessary	330°

2.3 Alarm output / error messages

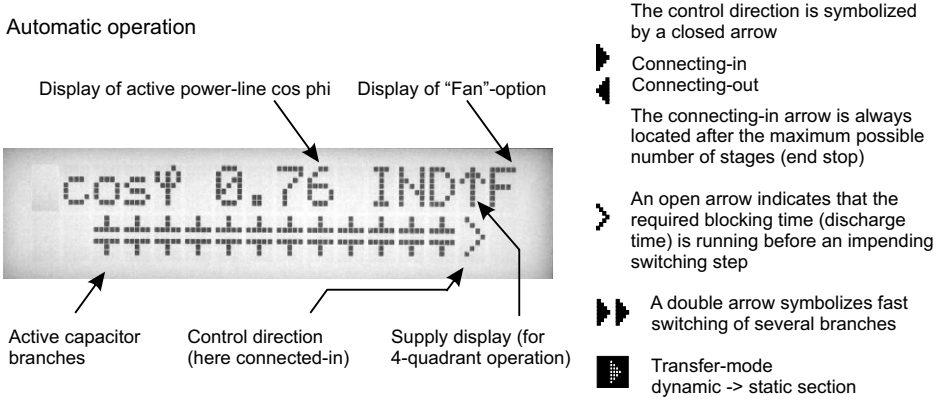
The alarm contact is closed in normal operation and opens in the event of a fault. The relevant fault is simultaneously shown on the display in plain text (alternating with the standard display in automatic operation). The following fault messages are displayed:

UNDER-COMPENSATED	Display and relay output
OVER-COMPENSATED	Display and relay output
OVERCURRENT	Display and relay output
MEASURING VOLTAGE ?	Display and relay output
OVERTEMPERATURE	Display and relay output
OVERVOLTAGE	Display and relay output
UNDERVOLTAGE	Display and relay output

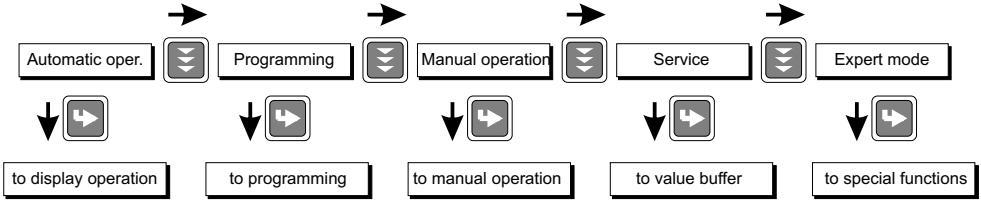
Additionally several messages for different operation states are generated. An individual adjustment resp. suppression of particular messages is possible in expert mode 2. During suppression, the indication of the message in the display, a possible release via alarm-relays and effects on the controlling process will be prevented.

Section 3 Operating modes

When the operating voltage is switched on, the BR6000 briefly displays its designation and software version, then changes to its normal operating status (automatic operation). The active cos-phi value is always displayed in the upper line and the currently connected capacitors are shown as symbols in the lower line (operating display).


Automatic operation
Display of active power-line cos phi
Display of "Fan"-option
cosϕ 0.76 IND↑F
Active capacitor branches
Control direction (here connected-in)
Supply display (for 4-quadrant operation)
The control direction is symbolized by a closed arrow
Connecting-in
Connecting-out
The connecting-in arrow is always located after the maximum possible number of stages (end stop)
An open arrow indicates that the required blocking time (discharge time) is running before an impending switching step
A double arrow symbolizes fast switching of several branches
Transfer-mode dynamic -> static section

Repeated pressing of the "Operating Mode" key takes the user to the various menus in sequence: **Auto**matic operation - **Program**ming - **Manual** (manual operation)- **Service - Expert** mode and back**.**



Section 4 Automatic operation - display of network parameter

The BR6000 is set to automatic operation as standard. Capacitor stages are then automatically connected in or out in order to reach the target power factor. This happens when the required reactive power exceeds the value of the smallest capacitor stage.
In automatic operation, various network parameters can be displayed by repeatedly pressing the "ENTER" key:

Action	Display		
ENTER	1 LINE VOLTAGE	in V	
ENTER	2 APPARENT CURRENT	in A	/ %
ENTER	3 REACTIVE POWER	in kvar	/ %
ENTER	4 ACTIVE POWER	in kW	/ %
ENTER	5 APPARENT POWER	in kVA	/ %
ENTER	6 DIFF. kVAR TO TARGET COS		
ENTER	7 FREQUENCY	in Hz	
ENTER	8 TEMPERATURE	in °C	/ °F
ENTER	Software version		
ENTER	Return to: 1		

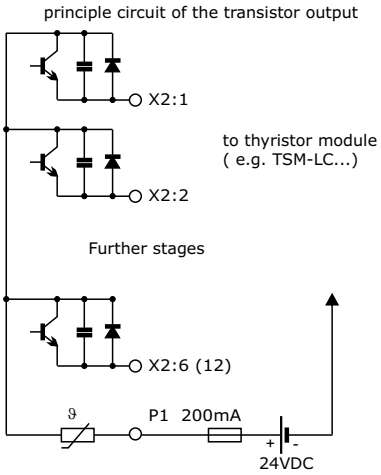
The power value specifies the total power (3-phase) assuming symmetrical load. If no key is pressed for 60 seconds, the display automatically returns to the operating status!

Switching outputs

Switching outputs:
The first 6 switching outputs of the BR6000-T6R6 are executed as transistor outputs.

These are used via an additional auxiliary voltage (10...24 VDC) for direct triggering of thyristor modules for dynamic power factor correction.
Max. current for a single output: 40 mA
Total current of all outputs: max 150 mA

Outputs 7…12 are relay outputs with potential free, normally open contact for max. 250 VAC
Max. current for a single output: 6A
Max. current of all outputs: 10 A



WARNING: Mixing-up of outputs and thus applying of 230 VAC on the transistor outputs will destroy the internal transistors !
P1= +24 VDC for transistors, P2 = L1 (230VAC) for relays

Section 5 Programming

Pressing the "Operating mode" key once takes the user from automatic operation to **Program**ming mode.
The upper display always shows the parameter and the lower one the set value. The values are changed by pressing the ↑ / ↓ keys. Subsequent pressing of the "ENTER" key stores the value and takes the user to the next parameter.
To quit programming mode in any step, press the "Operating mode" key.
Selection of different values for the transistor resp. relay section is marked by symbols T resp. R .

5.1. Program Menu

LANGUAGE SELECTION: This selects the language of the operating menu
(German, English, Spanish, French, Russian, Czech, Dutch, Polish)

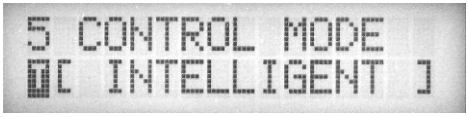
1 I-CONVERTER PRIM: [1000]A (5...13000)A
This selects the primary current of the current converter. Adjustment is via the ↑ / ↓ keys. Save and continue with ENTER

2 I-CONVERTER SEC: [5]A (5 / 1)
This sets the secondary current of the current converter
Selection via ↑ / ↓. Save and continue with ENTER

3 END STOPP: (dynamical part) (1...6)
T
By setting the end stopp, the number of active capacitor branches is matched to the respective capacitor bank. This is done via the ↑ / ↓ keys. The visible symbols of the capacitors correspond to the connected outputs.

4 CONTROL SERIES: (dynamical part) (1...20 + E)
T
The ratio of the capacitor branch power determines the control series, the power of the first capacitor always being assigned the value 1. The control series required for the compensation network is again selected via the ↑/↓ keys. If the required control series should exceptionally not be present (Annex 1), the user may define a special one (control series "E"). More on this point in the control-series editor in Annex 1.
Save and continue with ENTER

5 CONTROL PRINCIPLE: (dynamical part)
T
The control preference may be selected here:



SEQUENTIAL connection
LOOP connection
INTELLIGENT loop connection (default setting)
See Section 9 for an explanation of the various control modes.

6 POWER 1. STAGE: (dynam. part) (0.01 ... 255.99) kvar

T To determine the controller's response sensitivity, the dimensions of the network's smallest capacitor (stage 1) must be known. They are entered in two steps in kvar. The integral kvar values (before the comma) are initially selected via the ↑ / ↓ keys and saved with ENTER. The positions after the comma are then selected, again via the ↑ / ↓ keys. If the response sensitivity of the BR6000 is being undercut, a warning will occur (indication of **"!"** in the display)

7 CONNECTING TIME (dynam. part) (20 ... 1000) ms

T This refers to the time between connecting the capacitors to increase the momentary network capacitance. It should be noted that in practical operation the real connection time is affected by the discharge time (locking time).
Default setting: 1000 ms
Selection is performed via the ↑ /↓ keys. Continue with ENTER

8 DISCONNECTING TIME (dynam. part) (20 ... 1000) ms

T This refers to the time between disconnecting the capacitors to reduce the momentary network capacitance..
Default setting: 1000 ms
Selection is performed via the ↑ /↓ keys. Continue with ENTER

9 DISCHARGE TIME (dynam. part) (20 ... 1000) ms

T This is the time for which an individual output is blocked between connecting and disconnecting. This blocking time has priority over connecting and disconnecting times. It depends on the capacitor discharge rating and thus is specified by the compensation network.
Default setting: 200 ms
Selection is performed via the ↑ /↓ keys. Continue with ENTER

10 END STOPP (relay part) (7...12)
R Default: 12

11 CONTROL SERIES (relay part) (1...20 + E)
R Default 1:1:1:1:1:1

12 CONTROL PRINCIPLE (relay part)
R Default: Intelligent

13 POWER 1.STAGE (relay part) (0.01...255.99) kvar
R Default: 25.00 kvar

14 CONNECTING TIME (relay part) (1...1200) sec.
R Default: 40 sec

15 DISCONNECTING TIME (relay part) (1...1200) sec.
R Default: 40 sec

16 DISCHARGE TIME (relay part) (1...1200) sec.
R Default: 60 sec

17 EXTERNAL INPUT [without function]
possible:
- "2nd target cosPhi": input-signal activite 2nd target cos Phi
- "external Error": input-signal switched off the controller step by step

18 TARGET COS PHI: [0.98 IND] (0.8 ind ... 0.8 cap)

By setting the target cos phi, the power factor to be attained via the PF correction is defined. It is also set via the ↑ / ↓ keys.
Save and continue with ENTER

19 MEASURING VOLTAGE [230]V (30 ... 305)V

Programming the measuring voltage (L-N) of the system (direct measurement) or the L-N voltage on the primary side of a measuring-voltage converter. The values programmed here always refer to the voltage L-N in the system! The voltage is selected via the ↑ /↓ keys. Save and continue with ENTER.

20 V - CONVERTER RATIO [NO] (NO / 1.1 ... 990]

When a measuring-voltage converter (e.g. for HV- measurement) is used, its conversion ratio should be programmed here.
Example: Voltage converter 20000V:100 V => Conversion ratio: 200
Selection via the ↑ /↓ keys. Save and continue with ENTER.

21 ALARM TEMP [60]°C (50...85)°C

The alarm temperature programmed here is the temperature at which the capacitor stages are disconnected in steps. The controller's **alarm relay** responds after 60 seconds. At the same time the display shows the cause of the alarm (over-temperature). If the temperature drops again, the required branches are automatically re-connected in steps.
The selection is performed with the ↑ /↓ keys. Save and continue with ENTER.

22 MESSAGE RELAY (available only at version with Interface)

The message relay can be programmed for **one** of the following options as required:

"Fan": Relay switches the external cabinet fan.
(Default) The switching threshold can be programmed under point 23.
Display: **"F"**

"Supply": Message when active power is supplied. Display: **"S"**

"Undercurrent":This message appears whenever the measuring current is not reached. Display: **"U"** The signal is generated when the value drops below the response sensitivity of the controller.

"Module error": Display of a default signal taken via MMI6000 (only applicable with MMI6000 connected),
e.g. "overload system"
Control display **"M"**

23 FAN TEMP* [30]°C (15...70)°C
Input of the switching threshold for the fan.
* Only active if option 'Fan' is selected

24 DELAY-TIME OF ERROR-MESSAGES (0... 255) sec.
The delay time for error-messages in the display can be changed here.
Default: 10 sec.

CONTRAST [7] (5...10)
The display contrast can be changed with this menu point. The contrast depends to a certain degree on the viewpoint of the observer, i.e. on the insertion height of the equipment in the switching cabinet. The ↑ /↓ keys can be used to set an optimal contrast.

BASIC SETTING: [NO] (YES / NO)
When the selection is made with YES and confirmed with ENTER, all parameters are reset to the basic setting made by the PFC-system manufacturer.
(Optimal network values when the controller was supplied with a complete PFC-system). If the controller is supplied from the works, this point corresponds to the default setting.

CAUTION: All user settings are lost!

Programming is now completed. The controller has returned to point 1 of the programming menu.

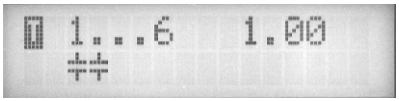
5.2 Programming lock

The BR6000 is equipped with a programming lock to ensure protection from unauthorized or inadvertent changes to the system parameters. The lock can be activated in expert mode. If the lock is active, all parameters can be checked but not changed.

Section 6 Manual operation (initial operation, maintenance, service) Programming of fixed stages

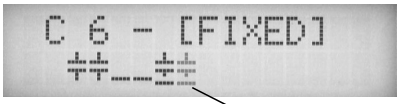
In manual operation, capacitor branches can be connected/disconnected **in the set control series and switching time -** irrespective of prevailing power-line conditions. Connections are made by pressing the ↑ or ↓ key.
The active operating status and active power factor are always shown on the display (self-explanatory).

Manual operation



Pressing ENTER takes the user to the menu point "Programming of fixed stages".
In the normal case, all stages are programmed for automatic operation (default setting).

Setting of fixed stages



AUTO OFF FIX (Currently selected stage blinks)

In special cases, all controller outputs (C1 - C12) may be permanently defined in succession (continued switching via ENTER) for the following statuses:

OFF: The output is continuously disconnected - e.g. for temporarily disconnecting a defective capacitor. The capacitor symbol for this output is faded out. Underlining appears.
AUTO: Automatic (normal) operation
The relevant output is marked by a capacitor symbol.
FIXED: The output is continuously connected, e.g. for fixed PFC. The output is marked by an underlined capacitor symbol.

The active stage is blinking. The required status is set via ↑ /↓. By pressing ENTER, the user saves this step and moves to the next stage.
The programmed statuses for the outputs also remain visible on the display in automatic operation.
After the required settings have been made, pressing the "Operating Mode" key takes the user to the next menu ("Service") or further to "Automatic Operation".

Section 7 Service menu

The service menu is reached by the operating-mode key.
The stored maximum values of the network parameters can be displayed here.

In addition, a fault memory is available, in which the last 8 fault states of the system are stored with fault code and in plain text. (This allows, for example, capturing short lived events of overtemperature or overvoltage)

Action	Display	
ENTER	1 max. VOLTAGE	in V
ENTER	2 max. REACTIVE POWER	in kvar / %
ENTER	3 max. ACTIVE POWER	in kW / %
ENTER	4 max. APPARENT POWER	in kVA / %
ENTER	5 max. TEMPERATURE	in °C / °F
ENTER	6 RESET the maximum values	
ENTER	ERROR MEMORY E[1] -	in plaintext
ENTER	ERROR MEMORY RESET	
ENTER	Back to 1	

Section 8 Expert mode 1 and 2

The expert mode is meant for the adjustment of values which normally should not be changed. As a protection against mal-operation this level has an access code branching out in Expert mode 1 or 2.

Password: Expert mode 1: " 6343" Expert mode 2: "2244"

8.1. Expert mode 1

2 BASIC SETTING NEW [NO] (NO/YES)
Storage of active programming as a new basic setting (usually performed by the PFC-system manufacturer). Caution: The original values are overwritten in the process!

3 SWITCHING POWER max [100/100] kvar (multiples of the smallest stage)
This factor specifies the maximum power which may be switched in one switching step. It can be used to control the intelligent control system, which switches several stages as a function of the power-factor requirement.
(This message will be displayed separately for dynamic and static part)

4 SWITCH.TRIGGER [66]% (30...100%)
Threshold for switching on of next stage. It should not be changed in the normal case!

5 OPERATING LOCK [NO] (NO / YES)

6 PHASE I [0°]
[L1] - L1 - N Adjustment of current phase position

7 PHASE U [0°]
L1 - [L1 - N] Adjustment of voltage phase position

Phase correction between voltage and current in the measuring system.
This setting allows to measure also in systems without neutral. However, the measuring voltage may not exceed 300 V (if necessary, a voltage converter must be used).

8 OUTPUT 1. STEP [0...255] (0...2550)
The range for entering the stage output can be increased to [0...2550] here, (e.g. for medium voltage measurement)

9 CONTROL [3] PHASE (3 / 1)
The measuring system of the controller is generally based on single-phase measurement. For all standard settings (three-phase), the measurement is converted and all outputs displayed as three-phase values (symmetry in grid assumed). In the single-phase setting, display and control apply only to the single-phase value measured.
(application: single-phase correction in asymmetrical grids).

10 PROTOCOL *only with option interface
[OFF]
[MODBUS RTU] MODBUS protocol for individual usage
[ASCII OUT] output of grid-values as ASCII-file (s.page 16)
[MASTER MMI] for communication with MMI6000

Depending on the protocol selection, the appropriate configuration-menu is offered:

11 BAUD RATE	[38400]	(4800...38400)	Transmission rate
12 Number of MMI	[1]	(1 ... 3)	Nos of connected MMI
13 ADDRESS	[1]	(1 ... 32)	Address
14 UPPER VALUE	[130]%	(110 ...200%)	Switch. threshold MMI
15 LOWER VALUE	[60]%	(30 ... 95%)	Switch. threshold MMI
16 TEST ATTEMPT	[10]	(3 ... 255)	
17 TEST-TIME	[10]	(3 ... 255)	
18 ASCII time	[10]sec.	(1 ... 255)	Repetition-time ASCII

8.2. Expert mode 2 (Password: 2244)
The additional 2nd expert mode includes all messages for operation, warning and error which are displayed by the BR6000. Here they may be deactivated separately. When deactivated, the indication of the message in the display as well as possible activation of the relay or effects on the control behavior are suppressed (detailed list of all messages in menu plan last page).

EXPERT MODE 2 [YES] (YES/NO)

Activation of particular operation, warning and error messages (s. above) (16 messages in total)

ALARM TIME [60] sec. (0...255 sec.)
Time after which the alarm relay will respond

Section 9 Control principle

The BR6000-T6R6 features 6 transistor outputs for the dynamic (fast switching) components and 6 relay outputs for the conventional capacitor steps switched via capacitor contactor.
If needed (target cos-phi not yet achieved) always the dynamic steps will be switched in to compensate the very fast changing loads.
In case the dynamic steps are switched in for a longer time, they transfer their load to the conventional capacitor outputs switched by relay. This happens with respect to the pre-set on- and off switching times of the relay section.
By transferring the loads the steps switched by transistors are free for the dynamic compensation.

The advantage of a mixed-dynamic compensation is the combination of a dynamic section (fast compensation of dynamic loads) and a conventional section of the system (for the ground load resp. for slow changing loads) in a single PFC system. By this combination a significantly better economic solution is achieved than compared to a purely dynamic system.

The control response of the BR6000 can be selected in programming mode. In principle, the controller has four different control modes:

1. Sequential connection
In sequential connection, the required capacitor stages are successively connected and disconnected in stages (last in - first out). The ranking of each step always corresponds to the power of the smallest stage.
Advantage: Exact definition of the next capacitor to be connected in each case
Disadvantage: Long settling time, high switching frequency of the small stages

In order to shorten the settling time, the BR6000 switches several stages simultaneously for a large power-factor requirement. This applies to all control types. The maximum dimensions of the simultaneously switching branches can be changed in expert mode. If the value of the smallest stage is pre-selected, the conventional sequential connection is obtained.

2. Loop connection
In this variant, the controller operates in loop mode (first in - first out) which minimizes the wear on the capacitor bank, i.e. where stages are of equivalent dimensions, the stage which was disconnected for the longest period of time is always connected next.
Advantage: Balanced utilization of equivalent stages and thus an increased operating life of the capacitor bank.

3. Intelligent loop connection (default setting)
The intelligent control principle combines the advantages of the network-sparing loop connection (first in - first out) with a much faster settling time, even for large load skips, and reaches this goal with the fewest possible switching operations of the capacitor stages. The optimized time response is achieved by the simultaneous switching of several or larger capacitor groups as a function of the missing power factor in the power line. Both the number of real switching frequencies of the capacitors as well as the turn-on times of the branches are considered.
Advantage: Reaches the target cos phi in a fast-optimized settling time with a low switching frequency of the capacitors.

Section 10 Interface (option)

The BR6000... is equipped with an RS 232 or RS 485 interface as an option.
It can be used to implement the following functions:

- ☑ Connection of a remote display (system accessories) for clear read-out of all measurements on large seven-segment triple displays
- ☑ Selection of MODBUS (see Annex 4) or ASCII (see table below) for permanent display of grid parameters in ASCII format). Any ASCII editor can be used.

NEW: Using with MMI6000 e.g. for measurement of inherent current of capacitor bank

The following data are permanently displayed and refreshed via ASCII (ASCII Protocol):

Voltage	e.g.	"230 V"	
Current	e.g.	" 85 A"	
Power factor	e.g.	"-0.98"	means: CAP
Reactive power	e.g.	"100 kvar"	
Active power	e.g.	"100 kW"	
Apparent power	e.g.	"100 kVA"	
Outputs	e.g.	"XXX--------"	means: 3 steps active

Section 11 Initial operation

The controller must have been installed before being set up and operated.
All network-specific parameters are fully programmed as described in section 5 (Programming) by being entered in sequence and stored. The controller is then set to automatic operation with the operating mode key. It is now ready for operation.

Section 12 Maintenance and warranty

The BR6000 should need no maintenance if the operating conditions are observed. However, it is recommended that a functional check of the controller be performed in conjunction with the regular checking of the capacitor bank. In the event of any interventions in the controller during the warranty period, all warranty claims lapse.

Section 13 Troubleshooting

Fault	Check / Solution
At target cos phi=1 and inductive load, switch-off or connection of capacitor in the corrected line Supply / Drawing mismatched	Check terminals of the measuring voltage and current (l and k)! Check phase position
Wrong line cos phi is displayed	See above
Display:"UNDER CURRENT"	Current in measuring range? Line interruption? Wrong current-converter factor? Current transformer short-circuited?
Display: "OVERCURRENT" Alarm relay: after 1 min.	Check current-converter ratio Go through measuring current range
Display: "UNDERCOMPENSATED" Alarm relay: after 1 min.	Check connection and phase position! All stages connected - target cos phi not reached: compensation network sufficiently dimensioned?
Display: "OVERCOMPENSATED" Alarm relay: after 1 min.	Check connection and phase position! Capacitive grid, although all stages disconnected
Display: "MEASUREMENT VOLTAGE ???" Alarm relay: after 1 min.	No measurement voltage!
Display: "OVERTEMPERATURE" Alarm relay: after 1 min.	Cabinet temperature too high: Outputs are switched off in stages irrespective of power-line conditions
Stages are disconnected for an inductive line or connected for a capacitive line	If a target cos phi is set which deviates from 1 despite an inductive line load, the display < (disconnect stages) may light up. The arrows indicate the control direction and not the line conditions.
The controller does not connect all stages, or cos phi does not change at the last stages	Check END STOPP !
In automatic operation, individual stages are not connected or disconnected	Check whether individual stages are programmed as fixed stages or OFF in the "Manual operation / Fixed stages" menu!
In strongly asymmetrically loaded lines, differences may occur between control response and power-factor measurement, as the power factor is measured in single phase.	Line measurements allow the most favorable phase for measuring the power factor to be determined. The current converter is set accordingly for the measuring current.
No operating voltage	Note: No display, alarm relay is activated (open)

Section 14 Technical data

Type series	BR6000-T6R6
Outputs	6 transistor, 6 relays
Languages	G / E / ES / RU / NL / CZ / PL / F
Switching power of outputs	6x transistor: 24 VDC, max. 40mA 6x relay: max. 230VAC / 6A
Number of active outputs	Programmable
Operation and display	Illuminated graphic display 2 x 16 characters with convenient operating level
Number of control series	20
User-defined control series	1
Control principle	Sequential connection, loop connection or self-optimized switching response Four-quadrant operation
Operating voltage	230 VAC, 50 / 60Hz
Measuring voltage	30...300 VAC (L-N), 50 / 60Hz
Measuring current	X : 5 / 1A selectable
Power drawn	< 5 VA
Sensitivity	50 mA / 10 mA
Target cos phi	0.8 inductive to 0.8 capacitive adjustable
Connecting time	separate selection for dynamic and relay section
Disconnecting time	separate selection for dynamic and relay section
Discharge time	separate selection for dynamic and relay section
Fixed stages/ skipped stages	Programmable
Alarm relay	Standard
No-voltage triggering	Standard
Display of power-line parameters	Power factor, voltage, apparent current, frequency, reactive-, active-, apparent power, missing kvar, temperature
Storage of maximum values	Voltage, reactive power, active power, apparent power, temperature
Temperature measurement range	0 - 100°C
Error memory	Last 8 error states are stored
Accuracy	Current, voltage: 1% Reactive-, active-, apparent power: 2%
Housing	Switchboard-integrated housing DIN 43 700, 144 x 144 x 53 mm
Weight	1 kg
Operating ambient temperature	-10 to +60°C
Protection type to DIN 40 050	Front: IP 54, Rear: IP 20
Safety guidelines	IEC 61010-1:2001, EN 61010-1:2001
Sensitivity to interference (industrial areas)	EN 50082-1:1995 IEC 61000-4-2: 8kV IEC 61000-4-4: 4kV
Option /S 232 (485)	Additional interface RS232 or RS485

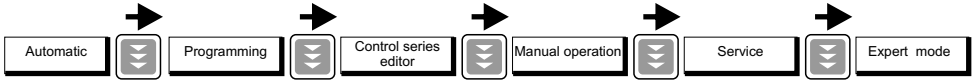
Annex 1: Table of control series

No.	control series T	control series R	Loop connection
1	1:1:1:1:1:1	1:1:1:1:1:1	Possible
2	1:2:2:2:2:2	1:2:2:2:2:2	Possible
3	1:2:3:3:3:3	1:2:3:3:3:3	Possible
4	1:2:3:4:4:4	1:2:3:4:4:4	Possible
5	1:2:4:4:4:4	1:2:4:4:4:4	Possible
6	1:2:3:6:6:6	1:2:3:6:6:6	Possible
7	1:2:4:8:8:8	1:2:4:8:8:8	Possible
8	1:1:1:1:2:2	1:1:1:1:2:2	Possible
9	1:1:1:1:1:6	1:1:1:1:1:6	Possible
10	1:1:2:2:2:2	1:1:2:2:2:2	Possible
11	1:1:2:2:2:4	1:1:2:2:2:4	Possible
12	1:1:2:2:4:4	1:1:2:2:4:4	Possible
13	1:1:1:2:2:2	1:1:1:2:2:2	Possible
14	1:1:2:3:3:3	1:1:2:3:3:3	Possible
15	1:1:2:4:4:4	1:1:2:4:4:4	Possible
16	1:1:2:4:8:8	1:1:2:4:8:8	Possible
17	1:2:2:3:3:3	1:2:2:3:3:3	Possible
18	1:2:3:4:4:8	1:2:3:4:4:8	Possible
19	1:2:2:4:4:4	1:2:2:4:4:4	Possible
20	1:2:2:2:4:4	1:2:2:2:4:4	Possible
"E"	Editor	Editor	Possible

Control series for the dynamic and the relay section are set independently from each other.

Control -series editor (programming up to a rating of 30)

The control-series editor allows the user to simply define his/her own control series if the required control series is not available for any reason.
The last control series - Control Series E - is selected by pressing the "Programming" key (point 4: Control series) and confirmed with ENTER. This leads to the insertion of an additional menu point in the main menu -> the control-series editor. It may be reached via the "Operating Mode" key.



In the control-series editor, all stages can be set in succession to the desired value with the selection keys ↑ / ↓. The next stage in each case is reached by pressing ENTER.
In the control series editor, the various steps may be programmed up to a rating of 30 (!).
The rating >9 is indicated in the display as follows:
10=A, 11=B, 12=C, 13=D, 14=E, 15=F, 16=G .... 30=U

NEW: **ALL** control series can be generated (even downwards). The customer will decide whether the generated control series is of sense.

The maximum number of stages can be limited by a programmed END STOPP < 12.

Annex 2: Default settings

Note: The following values for the default settings apply only if the controller is supplied directly from the manufacturer. Otherwise, these values may have been replaced by settings made by the manufacturer of the compensation network (optimal values for the relevant network).

No.	Parameter (* as option)	Default setting	Programmed values of this system (to be entered by manufacturer or operator)
0	LANGUAGE	ENGLISH	
1	I CONVERTER prim.	1000 A	
2	I CONVERTER sec.	5 A	
3 T	END STOPP	6	
4 T	CONTROL SERIES	1	
5 T	CONTROL PRINCIPLE	INTELLIGENT	
6 T	POWER 1. STAGE	25.00 kvar	
7 T	SWITCH- IN TIME	1000 ms	
8 T	SWITCH- OFF TIME	1000 ms	
9 T	DISCHARGE TIME	1000 ms	
10 R	END STOPP	12	
11 R	CONTROL SERIES	1	
12 R	CONTROL PRINCIPLE	INTELLIGENT	
13 R	POWER 1. STAGE	25.00 kvar	
14 R	SWITCH- IN TIME	40 s	
15 R	SWITCH- OFF TIME	40 s	
16 R	DISCHARGE TIME	60 s	
17	EXTERNAL INPUT*	WITHOUT FUNCT.	
18	TARGET COS-PHI (1 / 2)	0.98 IND	
19	MEASURING VOLTAGE	230 V L-N	
20	V- CONVERTER RATIO	- NO -	
21	ALARM TEMP.	55 °C	
22	MESSAGE RELAY *	FAN	
23	TEMP. FAN ON *	30 °C	
24	DELAY ERROR MESSAGE	10 sec.	
	CONTRAST	7	
	Capacitor stages	AUTO	Cannot be changed
	Password Expert mode 1	6343	Cannot be changed
	Password Expert mode 2	2244	
	Trigger value	66%	
	Max.simult.switch.power	4 x smallest stage	
	Operating lock	- NO -	
	Phase shift U/I	0 °	
	Power 1. stage	0...255 kvar	
	Control	3 - phase	
	Protocol*	MODBUS-RTU	
	Baudrate*	38400	
	Address*	1	
	Numbers of MMI6000*	1	

Annex 3: Capacitor current monitoring using MMI6000

Application

For permanent current monitoring inside the compensation system the MMI6000 is recommended as an accessory for the BR6000. This measuring device is able to determine the sum current of the complete PFC system as well as the current of single capacitor branches.
By monitoring the current of the installed capacitors, extraordinary grid conditions (e.g. harmonic currents which may cause an overload of capacitors) can be identified. In such a case, the power factor controller switches off the relevant compensation stages as long as the extraordinary situation continues. Monitoring of the capacitor current also means monitoring of the capacitor condition (damages, aging …) and thus gives the opportunity to avoid consequential damages.

The MMI6000 will improve the reliability and safety of a PFC-system.

Method of operation:

The MMI6000 measures the sum current inside the PFC system. For this a current transformer has to be installed at the power input of the compensation system. During each switching operation, the actual current change is measured and compared to the rated current of the switched capacitor(s). In between the switching operations the current of the complete system is monitored.

If the measured current of a step is too low (default 60%), this step is switched off. The relay is deactivated and the BR6000 display shows "E" (error) for this step. The alarm relay is activated. A reactivation of the step is possible in manual mode.
In case the current of a step is too high (default 130%), this step is also switched off. The BR6000 display shows an inverted capacitor symbol. The current is further on checked periodically is the rated current reached again, the step is reactivated.
Is the sum current of the complete PFC system too high (default 130%), stages are switched off one after another and alarm relay is set. Periodical measurements are performed to check whether the current reaches the nominal value again. If so, the step is reactivated.

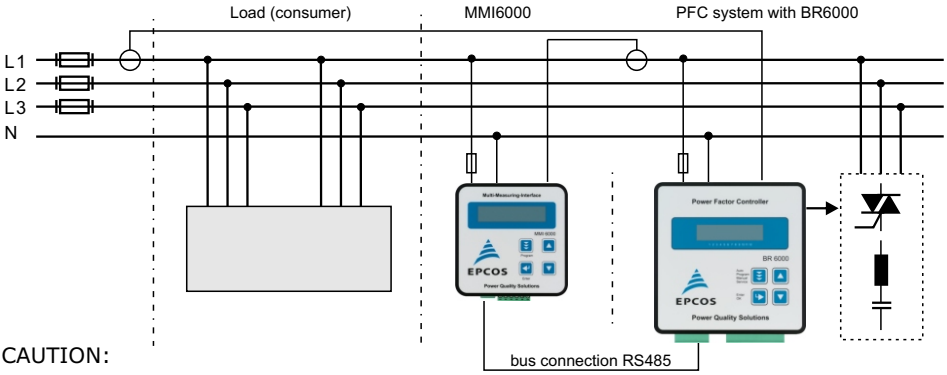
Settings MMI6000:

- Operation mode: Coupling MMI-BR6000-T
- Grid: 3-phase (DS)
- Baudrate: 38400

Settings BR6000-T6R6: (ExpertMode)

- Protocol: Master-MMI
- Baud rate: 38400
- Number of MMI connected
- Upper limit (%), lower limit (%)
  (limits of the capacitor / system output)

Principle circuit diagram:



CAUTION:

- For the bus-connection a shielded cable has to be used!
- Bus-connections (in and out) have always to be made directly to the relevant device!
- The terminating resistors inside the connected devices have to be activated (DIP-switch ON).
- Smallest switching time in this mode is 80 ms !

Annex 4: MODBUS-Protocol - Part 1: -only read-register (Functioncode 3)

F	Modbus No	Register / Function	Range	unit / digit	
3	0	Reactive power H-Part	32 Bit Long	1 var	
	1	Reactive power L-Part			
	2	Active power H-Part	32 Bit Long	1 W	
	3	Active power L-Part			
	4	Apparent power H-Part	32 Bit Long	1 VA	
	5	Apparent power L-Part			
	6	Diff. Reactive power H-Part	32 Bit Long	1 var	
	7	Diff. Reactive power L-Part			
	8	Actual system output (in var)	32 Bit Long	1 var	
	9				
	10	Actual system output (in %)	16 Bit	1 %	
	11	Voltage resolution of 0.1V, max. 300V	16 Bit	0.1 V	
	12	Current resolution of 0.1A	32 Bit Long	0.1 A	
	13				
	14	Voltage with resolution of 0.1V	32 Bit Long	0.1 V	
	15	(e.g. 2314 = 231,4V			
	16	Number of actual stages	16 Bit	1 stage	
	19	cos-Phi (100 = 1.00)	16 Bit	0.01 (- = cap)	
	20	Line voltage	16 Bit	1 V	
	21	Apparent current	16 Bit	1 A	
	22	Frequency	16 Bit	1 Hz	
	23	Temperature (cabinet)	16 Bit	1 °C	
	24	Temperature (controller)	16 Bit	1 °C	
	25 - 29	Several state messages	16 Bit		
	30	Outputs (relays)	16 Bit		
	51	cos-Phi (100 = 1.00)	16 Bit	0.01 (- = cap)	
	60	Failure - register	16 Bit	Bit 0 - 7	
	61	Warnings - register	16 Bit	Bit 0 - 7	
	62	Messages - register	16 Bit	Bit 0 - 7	
	71 - 82	Status outputs 1...12	16 Bit	0 = OFF	
				1 = ON	
	85 - 100	Register compressed values	16 Bit		
	101	Language	0 - 7	1 = English	
	102	I - converter prim.	1 - 255	0 = 5A ...	
	103	I - converter sek.	0 - 1	0 = 1A ...	
	104 T	End stopp	1 - 6		
	105 T	Control series	1 - 21		
	106 T	Control mode	0 - 2	0 = Sequ.	
	107 T	Power 1st stage	0 - 255		
	108 T	Power 1st stage	0 - 99		
	109 T	Switching - ON time	0 - 13	0 = 20ms	
	110 T	Switching - OFF time	0 - 13	0 = 20ms	
	111 T	Discharge time	0 - 13	0 = 20ms	
	112 R	End stopp	7 - 12		
	113 R	Control series	1 - 21		
	114 R	Control mode	0 - 2	0 = Sequ.	
	115 R	Power 1st stage	0 - 255		
	116 R	Power 1st stage	0 - 99		
	117 R	Switching - ON time	1 - 255	sec.	
	118 R	Switching - OFF time	1 - 255	sec.	
	119 R	Discharge time	1 - 255	sec.	
	120	External input	16 - 18	16 = without f.	
	121	Target cos Phi 1	80 - 120	80 = 0.8 cap.	
	122	Target cos Phi 2	80 - 120	80 = 0.8 cap.	
	123	Meas. voltage	29 - 255	Volt	
	124	Voltage converter ratio	10 - 216	10 = 1	
	125	Alarm temperature	30 - 75	°C	
	126	Message relay	6 - 9	6 = Fan	
	127	Fan temperature	15 - 70	°C	
	128	Delay Error display	0 - 255	sec.	

Part 2: - only-write -register (Functioncode 6)

	Modbus No.	Register / Function	Range	unit / digit	
6	1	Language	0 - 7	1 = English	
	2	I - converter prim.	1 - 255	1 = 5A ...	
	3	I - converter sek.	0 - 1	0 = 1A ...	
	4 T	End stopp	1 - 6		
	5 T	Control series	1 - 21		
	6 T	Control mode	0 - 2	0 = Sequ.	
	7 T	Power 1st stage	0 - 255		
	8 T	Power 1st stage	0 - 99		
	9 T	Switching - ON time	0 - 13	0 = 20ms	
	10 T	Switching - OFF time	0 - 13	0 = 20ms	
	11 T	Discharge time	0 - 13	0 = 20ms	
	12 R	End stopp	7 - 12		
	13 R	Control series	1 - 21		
	14 R	Control mode	0 - 2	0 = Sequ.	
	15 R	Power 1st stage	0 - 255		
	16 R	Power 1st stage	0 - 99		
	17 R	Switching - ON time	1 - 255	sec.	
	18 R	Switching - OFF time	1 - 255	sec.	
	19 R	Discharge time	1 - 255	sec.	
	20	External input	16 - 18	16 = without f.	
	21	Target cos Phi 1	80 - 120	80 = 0.8 cap.	
	22	Target cos Phi 2	80 - 120	80 = 0.8 cap.	
	23	Meas. voltage	29 - 255	Volt	
	24	Voltage converter ratio	10 - 216	10 = 1	
	25	Alarm temperature	30 - 75	°C	
	26	Message relay	6 - 9	6 = Fan	
	27	Fan temperature	15 - 70	°C	
	28	Delay Error display	0 - 255	sec.	
	40	Remote control Register value H = Data 1 (switch.power max = multiples of the smallest stage)	8 Bit	1 - max	
		Register value L = Data 2 0 - Remote OFF 1 - Switching DOWN, 2 - Stopp 3 - Switching UP	8 Bit	0 - 3	

Part 3 example

MODBUS - Functioncode 3 (only-read-register)
example meas. voltage

			answer	
Byte 1:	Slave Adresse	1	Sl. Adress	1
Byte 2:	Functioncode	3	Funct. code	3
Byte 3:	Reg.start adress “H”	0	No of Bytes	2
Byte 4:	Reg.start adress “L”	20	Data H	0
Byte 5:	Reg. number “H”	0	Data L	233
Byte 6:	Reg. number “L”	1	CRC L	121
Byte 7:	CRC testcode “L”	196	CRC H	202
Byte 8:	CRC testcode “H”	44		

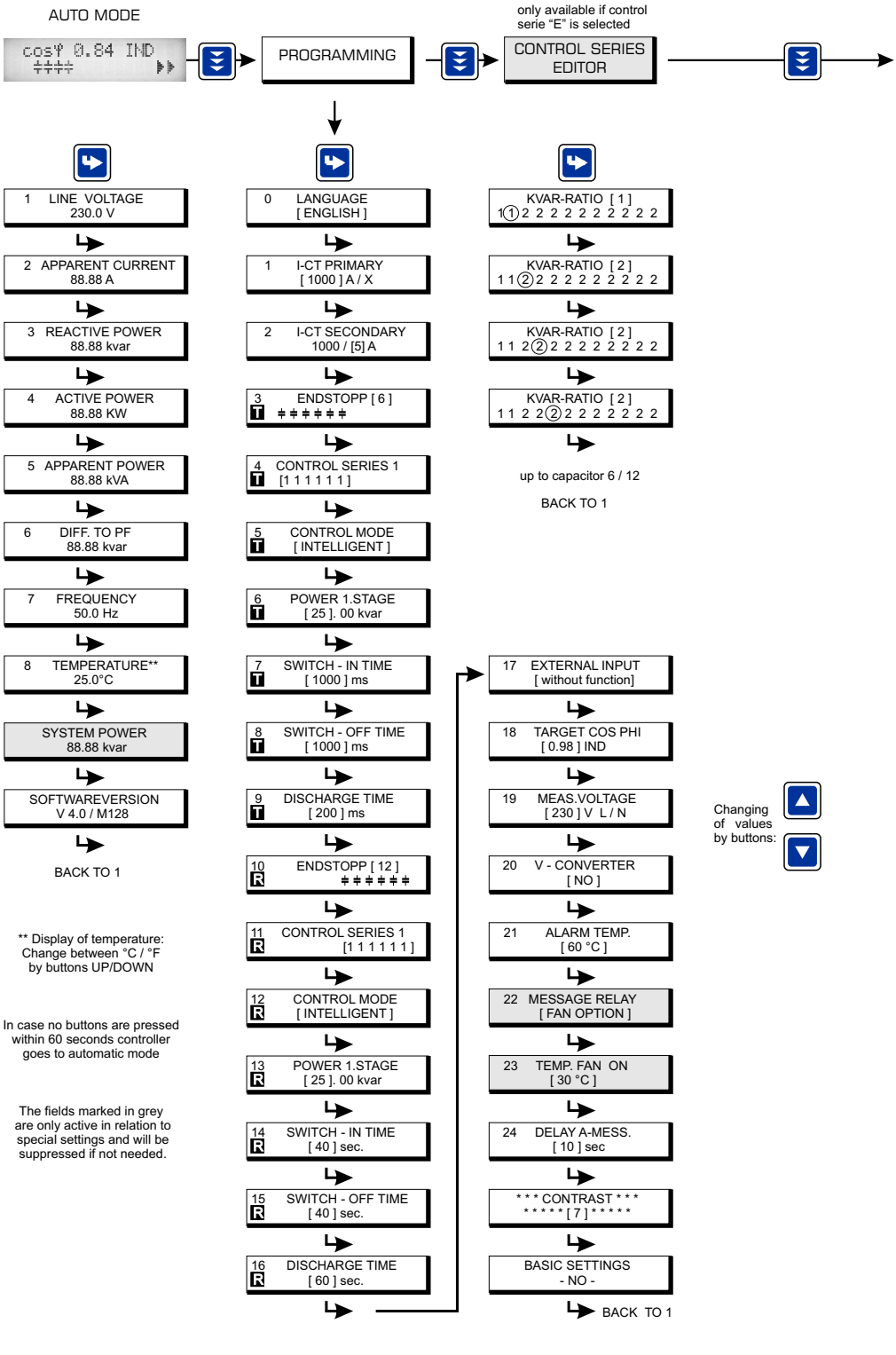
MODBUS - Functioncode 6 (only-write-register)
example remote-control (Remote-ON)

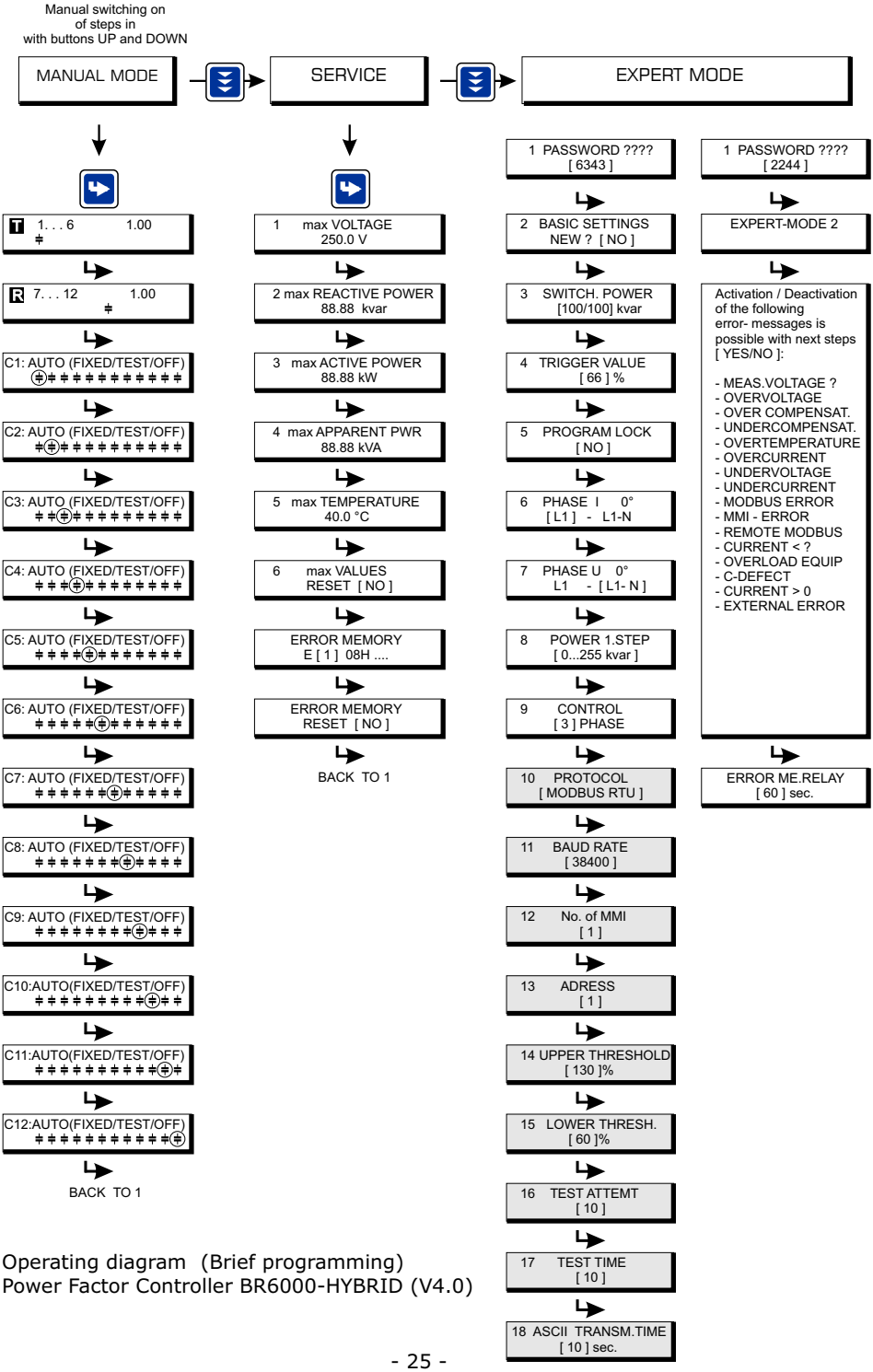
		answer
Slave Adresse	1	1
Functioncode	6	6
Registeradr. “H”	0	0
Registeradr. “L”	40	40
Reg.value H (Data1)	1*	1
Reg.value L (Data2)	3*	3
CRC testcode “L”	72	72
CRC testcode “H”	83	83

* Reg.value 1 = switch.-up with max. 1 step (1)
* Reg.value 3 = remote switching-up (3)

NOTE:
Due to the priority of the control function of the power factor controller before data exchange, please consider that per command 24 consecutive values maximum (s. table) are transferred blockwise.
Also, parameters should not be retrieved more than 1 x /second.

Settings: 8 data bit, 1 stop bit, no parity


AUTO MODE
cosϕ 0.84 IND
PROGRAMMING
only available if control serie "E" is selected
CONTROL SERIES EDITOR
1 LINE VOLTAGE 230.0 V
2 APPARENT CURRENT 88.88 A
3 REACTIVE POWER 88.88 kvar
4 ACTIVE POWER 88.88 KW
5 APPARENT POWER 88.88 kVA
6 DIFF. TO PF 88.88 kvar
7 FREQUENCY 50.0 Hz
8 TEMPERATURE** 25.0°C
SYSTEM POWER 88.88 kvar
SOFTWAREVERSION V 4.0 / M128
BACK TO 1
** Display of temperature: Change between °C / °F by buttons UP/DOWN
In case no buttons are pressed within 60 seconds controller goes to automatic mode
The fields marked in grey are only active in relation to special settings and will be suppressed if not needed.
0 LANGUAGE [ENGLISH]
1 I-CT PRIMARY [1000] A / X
2 I-CT SECONDARY 1000 / [5] A
3 T ENDSTOPP [6]
4 T CONTROL SERIES 1 [1 1 1 1 1 1]
5 T CONTROL MODE [INTELLIGENT]
6 T POWER 1.STAGE [25]. 00 kvar
7 T SWITCH - IN TIME [1000] ms
8 T SWITCH - OFF TIME [1000] ms
9 T DISCHARGE TIME [200] ms
10 R ENDSTOPP [12]
11 R CONTROL SERIES 1 [1 1 1 1 1 1]
12 R CONTROL MODE [INTELLIGENT]
13 R POWER 1.STAGE [25]. 00 kvar
14 R SWITCH - IN TIME [40] sec.
15 R SWITCH - OFF TIME [40] sec.
16 R DISCHARGE TIME [60] sec.
KVAR-RATIO [1]
KVAR-RATIO [2]
KVAR-RATIO [2]
KVAR-RATIO [2]
up to capacitor 6 / 12
BACK TO 1
17 EXTERNAL INPUT [without function]
18 TARGET COS PHI [0.98] IND
19 MEAS.VOLTAGE [230] V L / N
20 V - CONVERTER [NO]
21 ALARM TEMP. [60 °C]
22 MESSAGE RELAY [FAN OPTION]
23 TEMP. FAN ON [30 °C]
24 DELAY A-MESS. [10] sec
* * * CONTRAST * * * * * * * [7] * * * * *
BASIC SETTINGS - NO -
BACK TO 1
Changing of values by buttons:


Manual switching on
of steps in
with buttons UP and DOWN
MANUAL MODE
SERVICE
EXPERT MODE
T 1. . . 6 1.00
R 7. . . 12 1.00
C1: AUTO (FIXED/TEST/OFF)
C2: AUTO (FIXED/TEST/OFF)
C3: AUTO (FIXED/TEST/OFF)
C4: AUTO (FIXED/TEST/OFF)
C5: AUTO (FIXED/TEST/OFF)
C6: AUTO (FIXED/TEST/OFF)
C7: AUTO (FIXED/TEST/OFF)
C8: AUTO (FIXED/TEST/OFF)
C9: AUTO (FIXED/TEST/OFF)
C10:AUTO(FIXED/TEST/OFF)
C11:AUTO(FIXED/TEST/OFF)
C12:AUTO(FIXED/TEST/OFF)
BACK TO 1
1 max VOLTAGE 250.0 V
2 max REACTIVE POWER 88.88 kvar
3 max ACTIVE POWER 88.88 kW
4 max APPARENT PWR 88.88 kVA
5 max TEMPERATURE 40.0 °C
6 max VALUES RESET [NO]
ERROR MEMORY E [1] 08H ....
ERROR MEMORY RESET [NO]
BACK TO 1
1 PASSWORD ???? [6343]
2 BASIC SETTINGS NEW ? [NO]
3 SWITCH. POWER [100/100] kvar
4 TRIGGER VALUE [66] %
5 PROGRAM LOCK [NO]
6 PHASE I 0° [L1] - L1-N
7 PHASE U 0° L1 - [L1- N]
8 POWER 1.STEP [0...255 kvar]
9 CONTROL [3] PHASE
10 PROTOCOL [MODBUS RTU]
11 BAUD RATE [38400]
12 No. of MMI [1]
13 ADRESS [1]
14 UPPER THRESHOLD [130]%
15 LOWER THRESH. [60]%
16 TEST ATTEMT [10]
17 TEST TIME [10]
18 ASCII TRANSM.TIME [10] sec.
1 PASSWORD ???? [2244]
EXPERT-MODE 2
Activation / Deactivation of the following error- messages is possible with next steps [YES/NO]:
- MEAS.VOLTAGE ?
- OVERVOLTAGE
- OVER COMPENSAT.
- UNDERCOMPENSAT.
- OVERTEMPERATURE
- OVERCURRENT
- UNDERVOLTAGE
- UNDERCURRENT
- MODBUS ERROR
- MMI - ERROR
- REMOTE MODBUS
- CURRENT < ?
- OVERLOAD EQUIP
- C-DEFECT
- CURRENT > 0
- EXTERNAL ERROR
ERROR ME.RELAY [60] sec.

Operating diagram (Brief programming)
Power Factor Controller BR6000-HYBRID (V4.0)